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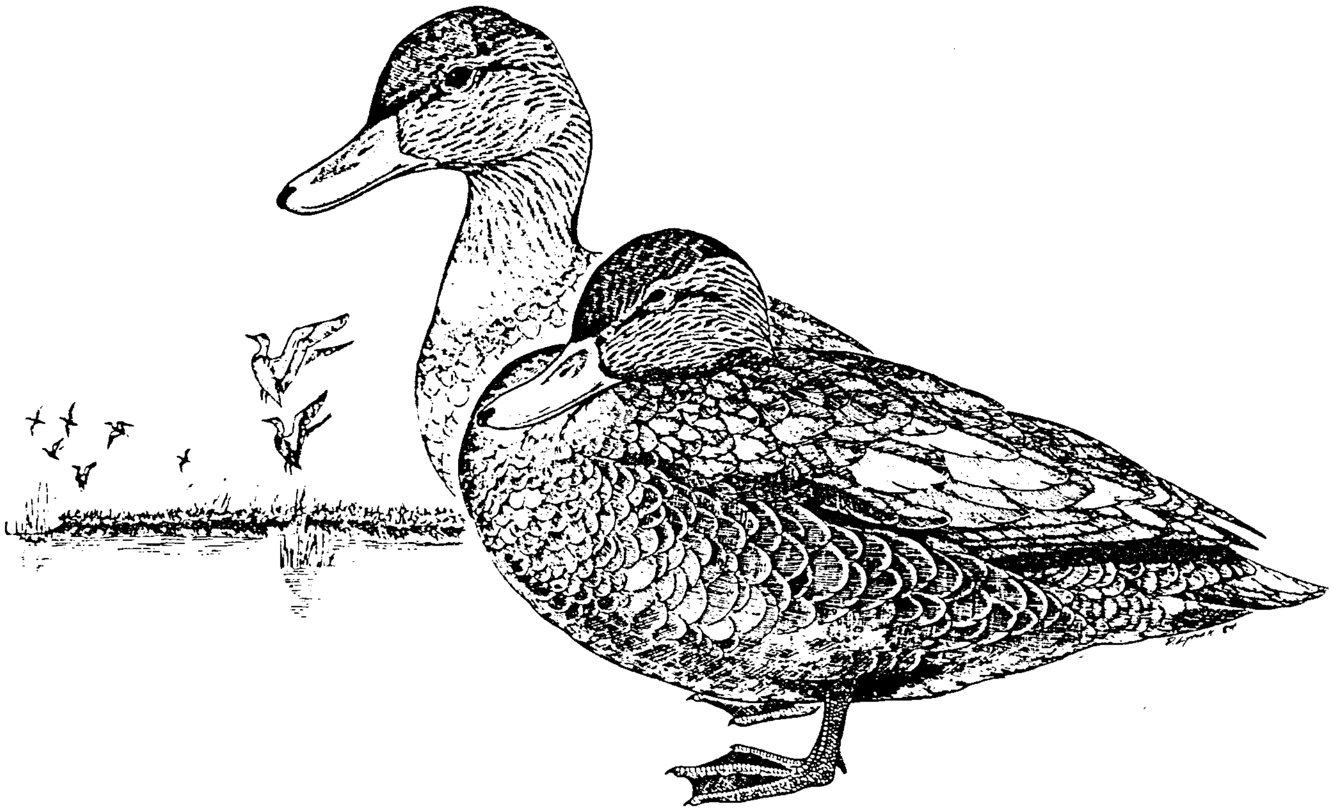
HABITAT SUITABILITY INDEX MODELS: AMERICAN BLACK DUCK (WINTERING)



Fish and Wildlife Service

U.S. Department of the Interior

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PREFACE

The habitat suitability index (HSI) models for American black duck are intended for use in impact assessment and management of winter habitat along the Atlantic coast. The models were developed from a review and synthesis of existing information and are scaled to produce indices of habitat suitability between 0 (unsuitable habitat) and 1 (optimal habitat) (U.S. Fish and Wildlife Service 1981). Assumptions used in developing the HSI models and guidelines for using models are described.

These models are hypotheses of species-habitat relations, not statements of proven cause and effect. The models have been partially validated (Lewis et al. 1984). The U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help increase the utility and effectiveness of this habitat-based approach to fish and wildlife management. Please send comments or suggestions to the following address:

National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458.

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September 1984

HABITAT SUITABILITY INDEX MODELS:

AMERICAN BLACK DUCK (WINTERING)

by

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Washington, DC 20240

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CONTENTS

ACKNOWLEDGMENTS

Drafts of the habitat suitability index models for American black duck were monitored, expertly reviewed, and constructively criticized by Fred Ferrigno, Principal Wildlife Biologist, New Jersey Division of Fish, Game, and Shellfisheries, Trenton, and Howard E. Spencer, Jr., Migratory Bird Research Leader, Maine Department of Inland Fisheries and Wildlife, Bangor. Jerry Longcore and Michael Conroy, Patuxent Wildlife Research Center, Laurel, Maryland, and Ronald E. Kirby, Office of Information Transfer, Fort Collins, Colorado, biologists of the U.S. Fish and Wildlife Service (FWS), provided helpful suggestions. Thorough evaluations of structure and functional relationships of models were provided by Carroll Cordes and Rebecca Howard of the FWS National Coastal Ecosystems Team, Slidell, Louisiana. The model and accompanying narrative were reviewed by personnel of the FWS Regional Office in Boston, Massachusetts, and the FWS Western Energy and Land Use Team in Fort Collins. Recent U.S. Department of Agriculture publications (Soil Conservation Service 1982a, b) have been used to standardize Latin names for plants.

AMERICAN BLACK DUCK (*Anas rubripes*)

INTRODUCTION

The American black duck, commonly known as the black duck, is migratory and has a wide geographic range. American black ducks breed from Cape Hatteras, North Carolina, west to the Mississippi River and north through the eastern Canadian boreal forest (Bellrose 1976). The winter range extends from the Rio Grande River on the Texas coast, northeast to Lake Michigan, east to Nova Scotia, south to Florida, and west to Texas (Wright 1954).

American black ducks arrive on their wintering habitats between September and early December and remain there until February to April (Bellrose 1976). Their preferred habitat varies considerably through the wintering range. Habitat use appears related to food availability, freedom from disturbance, weather, and often upon the presence of large bodies of open water. These interrelated elements are essential for meeting the energy demands and other nutritional requirements of black ducks in response to the rigors of cold weather and migration.

In the Atlantic Flyway, winter populations of American black ducks concentrate in marine and estuarine wetlands (U.S. Fish and Wildlife Service 1979). They use salt marshes and small tidal bays for feeding and loafing areas. In wintering areas north of Chesapeake Bay, American black ducks frequently feed on tidal flats and rest in emergent wetlands or on ice-free bays, rivers, and coastal reservoirs. In the Chesapeake Bay area, migrant and wintering American black ducks occupy a wide variety of habitats (Stewart 1962). They strongly favor brackish bays with extensive adjacent agricultural lands. Estuarine bays, coastal salt marshes, tidal fresh marshes, and adjacent impoundments receive high usage. American black ducks also concentrate in forested wetlands in and adjacent to estuaries in the South Atlantic Flyway, especially in Virginia and North Carolina.

SPECIFIC HABITAT REQUIREMENTS

Food

American black ducks are surface-feeding ducks or "dabblers," those ducks which feed primarily in shallow water or on land. Consequently, the food source must be on or near the water surface or shallowly buried in the substrate. They are crepuscular feeders and also feed during bright moonlight. In some coastal areas, American black ducks feed regularly at night as an adaptation to tidal regimes (Albright 1981) or hunting (Mendall 1949). Diet depends on the bird's age and food availability.

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Ice restricts feeding habitat (Kirby and Ferrigno 1980; Albright 1981), and American black ducks sometimes starve when foods become depleted or inaccessible (Hagar 1950; Palmer 1976). These ducks use high velocity rivers and tidal inlets where the ice-free period is prolonged by current. Tidal flats, mussel bars, and ledges are also important feeding areas because they are generally ice-free when exposed at low tide (Hartman 1963).

Hartman (1963) noted two types of intertidal mudflats. Narrow, 1.5-3 m (5-10 ft) wide, steep banks of rock and mud, covered with rockweed (*Fucus* sp. and *Ascophyllum* sp.) and scattered patches of smooth cordgrass, received little use by ducks. The more valuable intertidal zone was 9.1-304.8 m (30-1,000 ft) wide, gently sloping, with scant vegetation. These flats, when they supported 300-600 clams (bent-nosed clam and soft-shelled clam) per 1 m^2 (10.8 ft^2), attracted large flocks of black ducks. Flats that supported half that number of clams were less frequently used. Within the important mudflat habitats there is a microhabitat that is crucial for feeding during prolonged cold spells. This microhabitat occurs in small areas (sometimes less than 100 m^2 [1076 ft^2]) that remain ice-free near the low-tide line in places washed by strong currents.

Cover

American black ducks winter in wetlands or deepwater habitats and do not require uplands as a life requisite. Estuarine emergent wetlands are occasionally used as protective cover during winter storms or as a place to hide from hunters and predators. American black ducks also use estuarine and marine open water during winter storms and as loafing-resting sites where they can avoid hunters. The ducks loaf and feed on the southeast side of islands and peninsulas where there is maximum sunlight and protection from wind (Albright 1981). Shelter-producing high banks and the south side of dark-colored ledges where the ducks sunbathe are other favored sites. Winter cover requisites for black ducks are probably met wherever feeding habitat is adequate.

Interspersion

Specific data are not available on the ideal interspersion of American black duck habitat. A mixture of marine and estuarine habitats appears, however, to offer the greatest variety of food and cover and includes those habitats needed during severe weather. Ecotone (edge) between habitats is also an important factor affecting habitat suitability, but the optimal amount of edge per unit area is unknown.

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

These models were developed to evaluate habitat along the Atlantic coast within the winter range of American black ducks. Physical variables can be measured at any season, but biological variables should be measured in early winter before they are altered by duck use. The wetland and deepwater systems involved are the marine and estuarine systems of Cowardin et al. (1979). No model was developed for evaluating American black duck winter habitat on the Gulf of Mexico coast because of insufficient published data.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of suitable habitat required for a species to occupy an area. Little data on minimum habitat area for American black ducks were found in the literature. Coulter and Mendall (1968) listed the home range during breeding as 12.9 km^2 (5 mi^2). As previously noted, however, black ducks will fly as far as 40 km (25 mi) to feed on waste corn (Bellrose 1976). No minimum habitat area for wintering black ducks was identified for application of these models.

Verification level. Earlier drafts of the American black duck HSI models were reviewed by Fred Ferrigno, New Jersey Division of Fish, Game, and Shellfisheries, Trenton; and Howard Spencer, Jr., Maine Department of Inland Fisheries and Wildlife, Bangor. Their suggestions for model improvement were incorporated when possible, but the authors are responsible for the final version of the models.

These models have been partially verified (Lewis et al. 1984). Variables that measure physical habitat characteristics were compared to American black duck populations (1973-84) on 23 study sites along the Atlantic coast from Virginia to Maine. The variables measure abundance of important feeding habitats (shallow open water; tidal flats; vegetated wetland; and ponds, streams, and impoundments within vegetated wetland). Linear regressions indicated r values of 0.47 to 0.54 between average American black duck numbers and habitat variables. The tests indicated that these variables may explain 22% to 29% of the variation in distribution of black ducks. The importance of biological variables that measure abundance of foods (clams, snails, and aquatic plants) was not investigated.

Model Descriptions

Overview. Separate HSI models were developed to evaluate marine and estuarine open water and estuarine vegetated wetland habitats. Habitat variables for each model are linked to food, which we consider the most important life requisite for wintering black ducks (Figure 1). We assume that cover needs will be met wherever food requirements are satisfied.

Despite the importance of American black ducks as a waterfowl resource and the concerns over declining continental populations, relatively little quantitative habitat research has been done. The authors relied on literature and discussions with waterfowl biologists to identify key variables that characterize suitable habitat. The lack of precise habitat data required that we extrapolate the points at which habitat variables are less than required, ideal, or in excess of needs. Our assumptions and the literature basis for these are identified in Table 1.

Marine and estuarine open-water model. Marine and estuarine open-water (subtidal and intertidal) areas are important loafing, resting, feeding, and escape habitats for American black ducks. Four variables are thought to be important in limiting black ducks in these habitats. Two are physical features

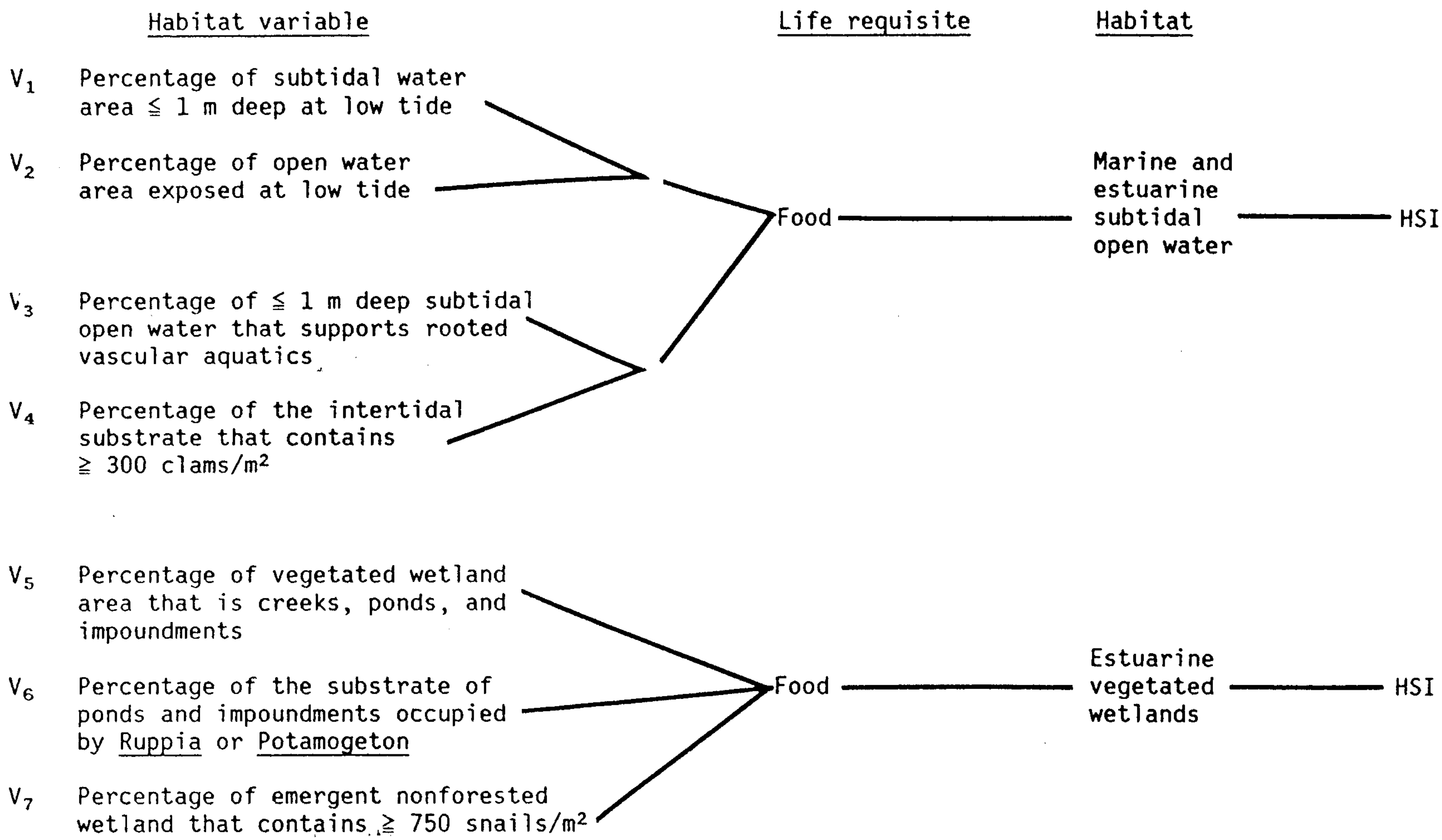


Figure 1. The relationship of habitat variables to winter habitat suitability index (HSI) values for the American black duck in Atlantic coastal habitats.

Table 1. Data sources and assumptions for black duck habitat suitability indices.

Variable and literature source	Assumptions
Marine and Estuarine Open Water	
V_1 Mendall (1949) Martin et al. (1951) Bellrose (1976) Kirby and Ferrigno (1980)	Ideal habitat exists when 70%-80% of marine and estuarine open water is ≦ 1 m (≦ 3.3 ft) deep at low tide. Habitat quality declines after the 80% level is exceeded.
V_2 Mendall (1949) Hartman (1963) Palmer (1976) Kirby and Ferrigno (1980)	Ideal habitat exists when 20%-60% of total marine and estuarine open water is exposed (tidal flats, banks, streambeds, and bars) at low tide. Habitat quality declines when the level exceeds 60%.
V_3 Coulter (1955) Cronan and Halla (1968) Johnsgard (1975) Bellrose (1976) Ferrigno (pers. comm.)	Ideal habitat exists when 20%-100% of subtidal open water ≦ 1 m (≦ 3.3 ft) deep is occupied by rooted vascular aquatic beds.
V_4 Hartman (1963) Kirby and Ferrigno (1980)	Ideal habitat exists in areas north of Cape Cod, Massachusetts, when 25% or more of exposed flats, streambeds, bars, and banks contain ≧ 300 clams/m² (≧ 28/ft²).
Estuarine Vegetated Wetland	
V_5 Hartman (1963) Johnsgard (1975) Bellrose (1976) Ferrigno (pers. comm.)	Ideal habitat exists when 20%-30% of estuarine emergent and forested wetlands consists of ponds, creeks, and impoundments. Habitat quality declines when the 30% level is exceeded.
V_6 Coulter (1955) Kerwin and Webb (1971) Johnsgard (1975) Bellrose (1976) Ferrigno (pers. comm.)	Ponds and impoundments are ideal habitat when 80%-100% of the substrate is occupied by *Potamogeton* and *Ruppia*.
V_7 Hartman (1963) Cronan and Halla (1968) Ferrigno (pers. comm.)	Snails are important foods and habitat is ideal when 25% of the emergent nonforested wetland contains ≧ 750/m² (≧ 70/ft²).

(water depth and presence of tidal flats), and two are biological characteristics (aquatic plant and clam populations). These variables are described below.

The percentage of subtidal open water ≦ 1 m (≦ 3.3 ft) deep, Variable 1 (V_1), is a measure of availability of shallow waters that provide important food resources. Because of its importance, V_1 is weighted in the equations presented later. The optimal amount of shallow waters is unknown, but we assume that habitat quality increases up to the point where 70%-80% of the subtidal open water is ≦ 1 m (≦ 3.3 ft) deep. Whenever these shallow (≦ 1 m) waters occupy more than 80% of the open water habitat, we assume that habitat quality declines because the amount of nearshore deep water is less than adequate. Open water exceeding 1 m in depth remains ice-free longer than the shallows (≦ 1 m) and sometimes provides better escape, loafing, and resting habitat.

Variable 2 (V_2), a measure of availability of tidal flat feeding habitat, is expressed as the percentage of total open water area exposed at low tide. Exposed areas include streambeds, banks, bars, and tidal flats. The importance of animal foods in winter diet of American black ducks is emphasized in the literature. These foods are principally found on exposed sites and include mussels, snails, clams, crabs, amphipods, and decapods. Such exposed sites are especially important for feeding when other habitats are covered by ice and snow. This variable is also weighted in the equations because of its importance. We assume that habitat is optimal when 20%-60% of the open-water substrate is exposed at low tide. When the exposed substrate exceeds 60%, we assume that habitat quality declines because of the decreasing availability of shallow waters that may provide alternative food sources and of deep open waters for escape and resting.

Variable 3 (V_3), a measure of quality of shallow water feeding habitat, is expressed as the percentage of shallow water (≦ 1 m or ≦ 3.3 ft deep at low tide) area that supports rooted vascular aquatic plant beds. Such aquatic beds, found mainly south of Cape Cod, Massachusetts, provide seeds and are habitat for some animal foods preferred by black ducks. We assume that habitat is optimal when 20% or more of the shallows are occupied by aquatic beds.

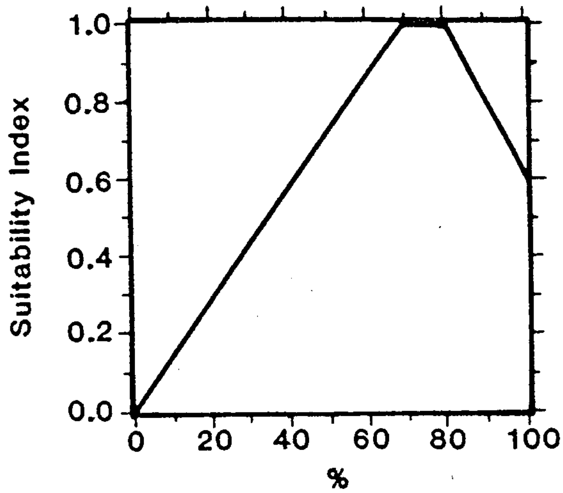
Variable 4 (V_4), a measure of quality of tidal flat feeding habitat, is expressed as the percentage of intertidal substrate that contains more than 300 clams/m^2 (28/ft^2). We assume that habitat is ideal whenever 25% or more of the exposed intertidal substrate supports populations greater than 300 clams/m^2 (28/ft^2). This variable is of primary importance when evaluating wintering habitat north of Cape Cod. Although vegetation becomes the prevalent item in the American black duck's diet south of Cape Cod, animal foods are still of some value and are considered in the model for that area also.

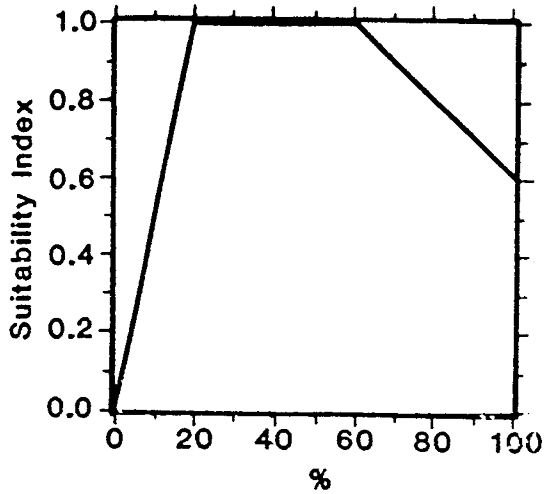
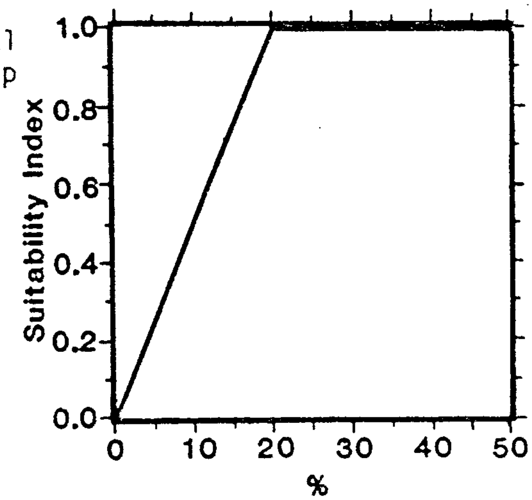
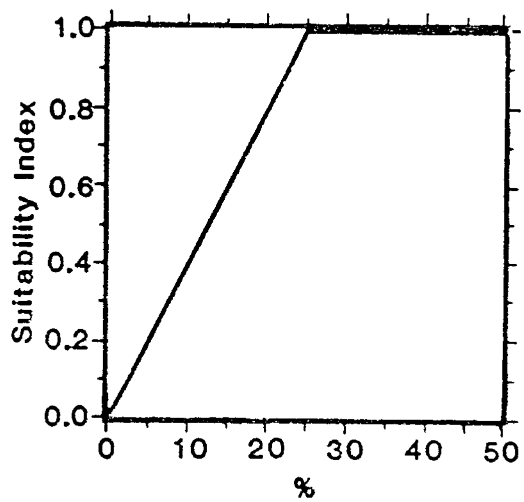
Estuarine vegetated wetland model. Estuarine intertidal emergent and forested wetlands and their associated ponds, channels, and impoundments provide food, protection from storms, and escape and resting cover for American black ducks. Variable 5 (V_5) is expressed as the percentage of emergent and forested wetland area covered by creeks, ponds, and impoundments. We assume that habitat quality increases until 20% of the area is made up of these water bodies that provide cover, and sometimes food, for the ducks. The mixture of water areas and vegetated wetland is assumed to be optimal when 20%-30% of the emergent or forested wetland is covered by ponds, creeks, or impoundments. Habitat quality declines when the 30% level is exceeded because less vegetated wetland is available for producing duck foods.

Variable 6 (V_6) is a measure of quality of pond and impoundment feeding habitat. The variable is expressed as the percentage of bottom substrate in ponds and impoundments that is occupied by Ruppia or Potamogeton. We assume that habitat is optimal when 80%-100% of the substrate samples include either of these two genera. Variable 7 (V_7), a measure of quality of emergent nonforested wetland feeding habitat, is expressed as a percentage. We assume that optimal emergent wetland habitat supports ≧ 750 snails/m² (≧ 70 snails/ft²). Habitat is optimal when 25% of the emergent marsh supports more than 750 snails/m².

Suitability Index (SI) Graphs for Model Variables

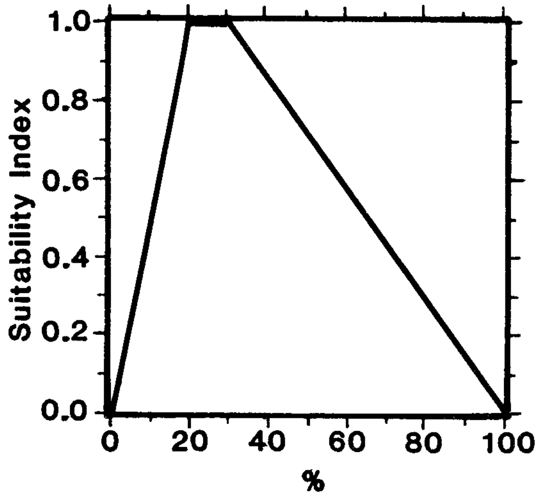
This section provides suitability index graphs that quantitatively describe the relationship betwen each habitat variable and suitability of marine (M) and estuarine (E) habitat for American black ducks. The previously discussed data sources and assumptions associated with development of the SI graphs are listed in Table 1. The SI values are read directly from the graph (1.0 = optimal habitat; 0 = unsuitable habitat).

Habitat	Variable		Suitability Graph
M,E	V_1	Percentage of subtidal open water ≦ 1 m deep at low tide.	

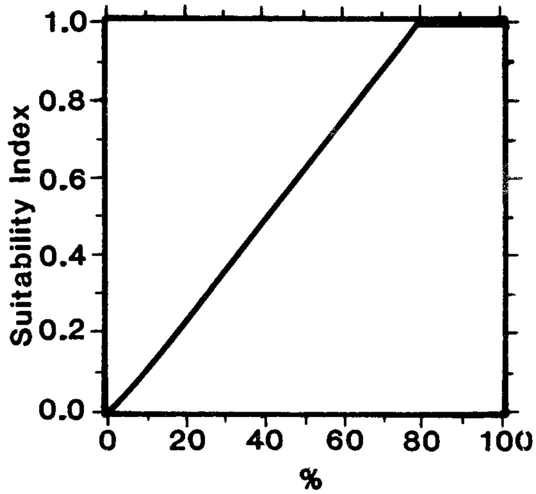
Habitat	Variable		Suitability Graph
M,E	V_2	Percentage of total open-water area that becomes exposed streambeds, banks, bars, and tidal flats at low tide.	
M,E	V_3	Percentage of subtidal open water (≦ 1 m deep at low tide) that supports rooted vascular aquatic plants.	
M,E	V_4	Percentage of area of tidal flats, streambeds, banks, and bars that have ≧ 300 clams/m^2.	

Habitat | Variable | Suitability Graph

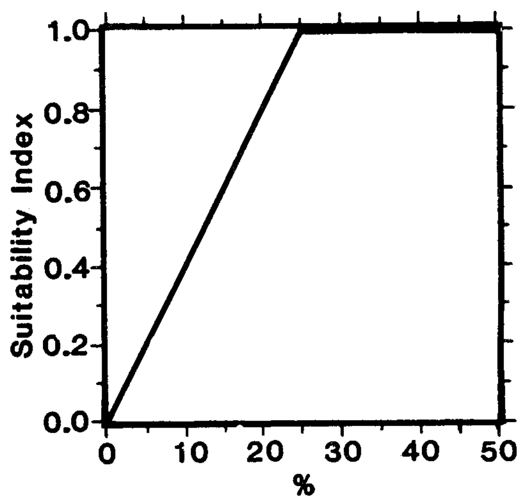
E V_5 Percentage of estuarine emergent and forested wetlands occupied by creeks, ponds, and impoundments.



E V_6 Percentage of substrate samples, from ponds or impoundments, that is occupied by *Ruppia* or *Potamogeton*.



E V_7 Percentage of emergent marsh that supports $\geqq$ 750 snails/m^2.



HSI Determination

The following equations describe relationships among habitat variables included in the American black duck HSI models. Two equations are available for use whenever marine or estuarine subtidal open water is present. The first equation, for areas north of Cape Cod, Massachusetts, recognizes the importance of clams as winter food in those North Atlantic areas that experience comparatively severe winter weather. The second equation is for use on sites south of Cape Cod. The third equation is used when intertidal estuarine vegetated (emergent or forested) wetlands are present.

Habitat	Equation
M and E open water north of Cape Cod, Massachusetts	$\left[\left(\frac{SI_{V_1} + SI_{V_2}}{2}\right)^2 \times SI_{V_4}\right]^{1/3}$
M and E open water south of Cape Cod, Massachusetts	$\left[\left(\frac{SI_{V_1} + SI_{V_2}}{2}\right)^2 \times \left(\frac{SI_{V_3} + SI_{V_4}}{2}\right)\right]^{1/3}$
E vegetated wetlands	$\frac{2\ SI_{V_5} + SI_{V_6} + SI_{V_7}}{4}$

Data representing three hypothetical study areas were used to calculate sample HSI values (Table 2). Data set 1 represents an open-water area north of Cape Cod with a moderate clam population. The second data set represents an open-water area south of Cape Cod where habitat suitability is limited by low clam populations and sparse aquatic vegetation. The emergent wetland represented by data set 3 supports high populations of snails and is fairly good wintering habitat for American black ducks.

Field Use of Models

The level of detail given to a particular application of these models will depend on time, money, and accuracy constraints. Detailed field sampling of all variables will provide the most reliable SI values. Measurement techniques in Table 3 are suggested for variables included in the models, and possible problems that may arise during applications of the models are described below.

The HSI models presented may be used to predict future habitat value after an area has been altered by development projects. In such situations, it is difficult to predict future values for V_4 and V_7 because these variables require information on clam or snail populations. If the effect of a project on clam or snail populations is unknown, the future values of V_4 and V_7 can be assumed to be equal to their present values.

Another difficulty that may be encountered during application of the models concerns project areas that contain both subtidal open water and emergent or forested wetland habitat. Because American black ducks can use either habitat type exclusively, the HSI values should be determined for each habitat separately. If, however, a single overall HSI value is necessary for mitigation planning, the following equation can be used.

$$HSI = A_{ow}\ HSI_{ow} + A_{vw}\ HSI_{vw},$$

where

HSI_{ow} = HSI for the open-water portion of the project area

HSI_{vw} = HSI for the vegetated (emergent or forested) wetland portion of the project area

A_{ow} = Percentage, expressed as a decimal, of project area that is subtidal open water

A_{vw} = Percentage, expressed as a decimal, of project area that is vegetated wetlands

($A_{ow} + A_{vw}$ must equal 1)

Interpreting Model Outputs

HSI values obtained by applying these models indicate a habitat's potential to support American black ducks during winter. The primary value of an HSI is for comparing the suitability of two different areas or for comparing one area at two points in time. These models may not be good predictors of American black duck wintering populations because many nonhabitat factors excluded from the models (e.g., predation, disease, weather conditions, human disturbance, competition with other ducks) can limit population levels.

Table 2. Calculation of suitability indices (SI) and the habitat suitability index (HSI) for sample data sets by using the black duck habitat variables (V_n) and model equations.

Model component	Data set 1		Data set 2		Data set 3	
	Data	SI	Data	SI	Data	SI
V_1	50%	0.71	25%	0.36	-	-
V_2	70%	0.90	5%	0.25	-	-
V_3	-	-	5%	0.25	-	-
V_4	6%	0.24	2%	0.08	-	-
V_5	-	-	-	-	10%	0.50
V_6	-	-	-	-	70%	0.88
V_7	-	-	-	-	24%	0.96
Open Water HSI	0.54		0.25		-	
Estuarine vegetated wetland HSI	-		-		0.71	

Table 3. Suggested methods for measuring variables used in the American black duck HSI models.

Variable	Methods
V_1	Use coastal maps that depict the 1-m (3.3-ft) contours at low tide. Where such maps are unavailable, random depth sampling will be necessary along transect lines. Measure area by use of a planimeter or a dot grid. Calculate the percentage of subtidal open water that is ≦ 1 m (≦ 3.3 ft) deep.
V_2	Maps from the U.S. Geological Survey, Coast Guard, and U.S. Department of the Interior often depict tidal flats and similar exposed sites. Other maps show water depth contours and, with knowledge of local tides, one can identify areas that will be exposed at low tide. If adequate maps are lacking, aerial photographs taken at low tide may be used to identify the exposed areas. When the area has been measured with a planimeter or dot grid, calculate the percentage that area is of the total open-water area. If suitable maps and aerial photographs are unavailable, random or systematic field sampling techniques can be used to determine the percentage.
V_3	Sample at randomly selected sites to determine the percentage of shallows (≦ 1 m or 3.3 ft deep) that are occupied by rooted vascular plants.
V_4	Randomly sample along lines perpendicular to the waters edge. Use an Ekman dredge to sample from the top 10.1 cm (4 inches) of mud during September through November. Wash, screen, and count clams. Calculate the percentage of sample plots that contain ≧ 300 clams/m² (≧ 28 clams/ft²).
V_5	Coastal maps usually depict ponds, creeks, and impoundments. Aerial photographs are also suitable. A dot grid or planimeter can be used to measure the area involved. Calculate the percentage that this area represents of all emergent and forested wetlands.
V_6	Bottom samples are taken at random using a plant dredge. Calculate the percentage that is made up of <u>Ruppia</u> and <u>Potamogeton</u>.
V_7	Numbers of snails are counted on randomly selected plots in the emergent wetland and its seaward edge. Counts are converted to total snails/m². Calculate the percentage of nonforested emergent marsh that supports ≧ 750 snails/m² (≧ 70 snails/ft²).

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16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop models suitable for evaluating winter habitat of American black duck (Anas rubripes). The models are scaled to produce indices of habitat suitability between 0 (unsuitable habitat) and 1 (optimal habitat) for Atlantic coastal areas of the continental United States. Habitat suitability indices are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

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